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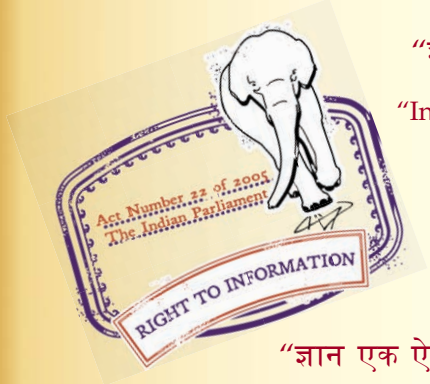

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"Knowledge is such a treasure which cannot be stolen"

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IS : 6609 (Part II/Sec 2) - 1974

(Reaffirmed 1998)

Indian Standard

METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART II EXPLOSIVES

Section 2 Explosives, Permitted

(First Reprint APRIL 1983)

UDC 662·1/·4 : 620·1

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4

January 1975

Indian Standard

METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART II EXPLOSIVES

Section 2 Explosives, Permitted

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Indian Standard

METHODS OF TEST FOR COMMERCIAL BLASTING EXPLOSIVES AND ACCESSORIES

PART II EXPLOSIVES

Section 2 Explosives, Permitted

0. FOREWORD

0.1 This Indian Standard (Part II/Sec 2) was adopted by the Indian Standards Institution on 1 October 1974, after the draft finalized by the Explosives and Pyrotechnics Sectional Committee had been approved by the Chemical Division Council.

0.2 The explosives industry in India was for a considerable time confined only to the ordnance factories. However, during the last decade other manufacturing units have come into existence. It was, therefore, considered necessary to formulate specifications for various explosives and explosive accessories produced by the industry. Before laying down specifications, it was felt necessary to prepare standard methods of test.

0.3 Testing of commercial explosives is of utmost importance for ensuring their safety during transport and handling, stability in storage and adequate life and performance under all conditions of use. Test methods included in this standard cover these aspects for all the groups of explosives under consideration.

0.4 Depending upon the origin and type of the explosives, a large number of test methods are in vogue, which though similar in nature, differ in minor details of test procedure and expression/interpretation of results.

0.5 It is a difficult task to select a particular method as the best. Therefore, choice has been effected in favour of those methods, for which sufficient experience and experimental data are available and which are mutually acceptable to all concerned, namely, the producers, the inspecting authorities and the consumers in the field.

0.6 The test methods prescribed in this standard cover both the general and the permitted explosives and accessories like detonators, detonating fuses and safety fuses. They do not cover all items but include those which are currently used and manufactured in the country. The methods of tests for

various explosives and explosive accessories are covered under different parts of this standard:

Part I	Gun powder
Part II/Sec 1	Explosives, general
Part II/Sec 2	Explosives, permitted
Part III	Detonators, general and permitted
Part IV	Detonating fuses
Part V	Safety fuses

0.7 Methods for assessing the fume characteristics of explosives, deflagration test and free suspension test are under investigations and would be included later, if considered necessary.

0.8 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part II/Sec 2) prescribes the methods of test for permitted explosives used for commercial blasting purposes.

1.1.1 The tests prescribed in the standard are:

a) the gallery test, and

b) the continuity of detonation test.

1.1.2 These tests are in addition to those prescribed for general explosives in IS : 6609 (Part II/Sec 1)-1974†.

2. GROUPS OF PERMITTED EXPLOSIVES

2.1 Grouping of permitted explosives is linked with the classification of mines. The seams have been classified by the Directorate General of Mines Safety, Government of India as first, second and third degree of gasiness on the basis of rate of methane emission. The explosives for these seams are divided into the following four types:

Type P (o) — Permitted (ordinary); for use only in first degree gassy seams.

Type P (eqs) — Permitted (equivalent to sheath); they are primarily designed for use in second and third degree gassy seams but also can be used for first degree gassy seams.

*Rules for rounding off numerical values (*revised*).

†Method of test for commercial blasting explosives and accessories: Part II Explosives; Sec 1 Explosives, general.

Type P (r) — Permitted (for ripping); they are primarily designed for delay firing in ripping.

Type P (s) — Permitted (for solid blasting); they are primarily designed for delay firing in solid coal. They can also be used for instantaneous blasting with under-cuts, over-cuts, mid-cuts and side-cuts in all categories of seams.

3. GALLERY TEST

3.0 General — For all types of explosives, the gallery test consists of:

a) firing charges into flammable atmosphere containing methane or natural gas-air mixture; and

b) additionally, for Types P (o), P (eqs), and P (s), firing charges into coal dust.

For each type of explosive, charges are fired when loaded in the bore of a cannon which discharges into a cylindrical steel gallery (*see* **3.1.4**) containing the gas mixture or the coal dust. For Type P (r) explosives, charges are also fired into a gas mixture contained in steel assemblies of prescribed shape and size called 'break test apparatus No. I, II and III' (*see* **3.1.6**). The density, velocity of detonation, diameter and gap sensitivity are measured and recorded.

3.1 Materials and Apparatus

3.1.1 *Flammable Gas-Air Mixture* — Wherever flammable gas-air mixture is specified the flammable gas shall be pure methane, firedamp or natural gas.

3.1.1.1 In the case of pure methane and firedamp, the flammable gas-air mixture shall contain $9 \pm 0{\cdot}25$ percent of flammable gas.

3.1.1.2 In the case of natural gas, the flammable gas-air mixture shall contain $8 \pm 0{\cdot}25$ percent of flammable gas (natural gas).

NOTE — The percentage of natural gas specified in **3.1.1.2** is based on the average composition of the gas available in Duliajan, Assam. The average composition of natural gas available at different sources (bore holes) in Duliajan is as given below:

Constituent	*Percent by Volume*
Methane	86·3
Ethane	6·2
Propane	3·1
Iso-butane	0·6
n-butane	0·8
Iso-pentane	0·2
n-pentane	0·1
Hexanes	0·1
Nitrogen	0·1
Carbon dioxide	2·5

Relative density — 0·681

3.1.2 *Coal Dust* — Wherever coal dust is specified, it shall contain approximately 40 ± 2 percent of volatile matter (calculated on an ash-free dry basis) and shall be ground to such a degree of fineness that 85 percent by mass passes through 63-micron IS Sieve.

3.1.3 *Cannons* — The cannons used are of two types, namely, Type I and Type II.

3.1.3.1 *Type I* — It is used for all shots fired into the cylindrical gallery and for all shots fired in break test apparatus No. I. This cannon is a steel cylinder, 45 cm or more in diameter, 154·2 cm in length and having an axial bore which when new is 55 mm in diameter (*see* Note under **3.2.4**) and 120 cm long. The cannon is rotated successively through 90° after 60 shots had been fired. After firing 240 shots in this way, the inner liner of the cannon shall be replaced.

3.1.3.2 *Type II* — It is a steel cylinder about 30 cm long and 30 cm in diameter. It has an axial bore which when new is 55 mm in diameter and which passes right through the cannon. Two Type II cannons are used for shots in break test apparatus No. III.

3.1.4 *Cylindrical Steel Gallery* — as shown in Fig 1.

3.1.4.1 The cylindrical gallery is a horizontal steel shell 152 cm in diameter, 19 metres in length and of minimum wall thickness of 15 mm. One end of the gallery is open while the other end is closed by a steel plate having a central hole of size bigger than that of the cannon-bore. The first 5·5 metres from the closed end is sealed by a bitumen impregnated kraft paper or polyethylene diaphragm and constitutes the ' explosion chamber '. There is a provision for the introduction of flammable gas and the circulation of the flammable gas-air mixture in the chamber. There is also provision for suspending bags containing coal dust. There are in the explosion chamber, observation windows for observing ignitions and terminals for connecting the detonator leading wires and for connecting the electrical fuse wire, besides the tap for drawing check samples of methane or natural gas-air mixture for analysis. There are vents at the top of the explosion chamber for pressure release.

3.1.4.2 In use, the cannon is charged with the explosive under test. It is subsequently moved horizontally on rails or otherwise until it presses against the closed end of the gallery, with which it makes a gas-tight seal. The axis of the cannon bore and the cylindrical gallery are in line.

3.1.5 *Enclosure for Break Test* — It is an enclosure in the form of a pit 240 × 240 × 150 cm, the depth of 240 cm being exclusive of the sand occupying the bottom portion of the pit. The walls of the pit are of concrete. This pit is provided with facilities for introduction of flammable gas, proper mixing of flammable gas and air and for the circulation of the flammable gas-air mixture. This enclosure is used in conjunction with break test apparatus No. I, II and III.

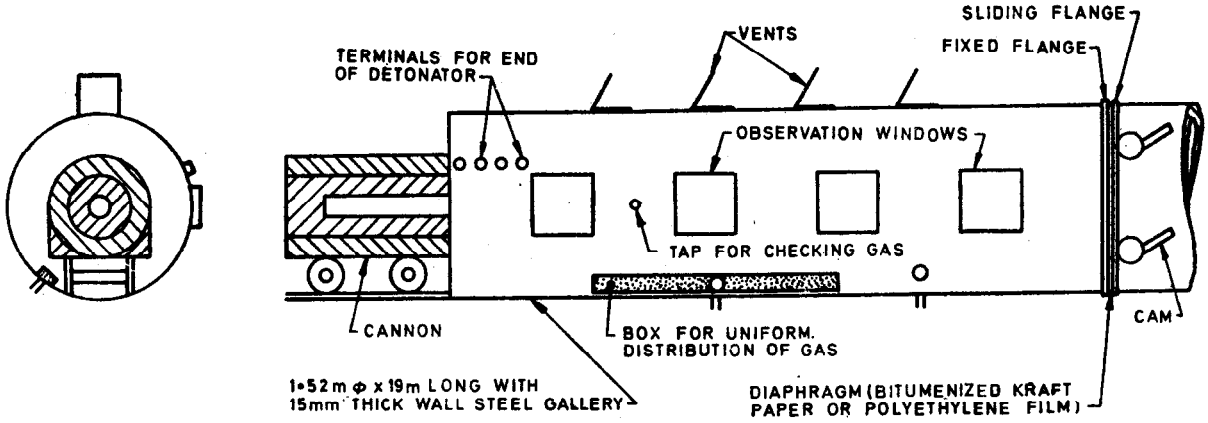


FIG. 1 CYLINDRICAL STEEL GALLERY FOR TESTING PERMITTED EXPLOSIVES

3.1.6 *Break Test Apparatus*

3.1.6.1 *Break test apparatus No. I* — as shown in Fig 2A. It is an assembly of Type I cannon and two stout plates, each 160 × 160 × 7·5 cm, in the enclosure for break test. The volume of the enclosure is 5·7 m^3. The cannon is mounted with its axis vertical and its mouth upwards. The plates are horizontal and the lower one is bored centrally so as to be a close fit to the connon, the upper face of which is flush with the upper surface of the plate. The upper plates is mounted so that its lower surface is 15 cm above the upper surface of the lower plate and is so held by stout pillars passing through both plates near their corners. The enclosure for break test completely surrounds both plates and the mouth of the cannon.

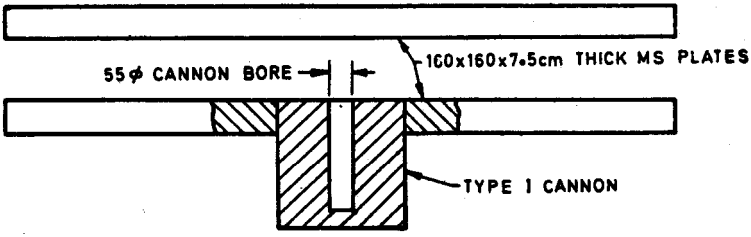
3.1.6.2 *Break test apparatus No. II* — as shown in Fig. 2B. It is an assembly of two stout plates, each 160 × 160 × 7·5 cm, with or without subsidiary steel plates of the same aggregate area, in the enclosure for break test. The volume of the enclosure is 5·7 m^3. The plates are horizontal and are held apart at distances which may be varied between 5 and 15 cm by stout pillars passing through both plates near their corners. If subsidiary plates are not used, the lower plate has a semi-cylindrical groove, 45 mm in diameter, along the centre line cut from one edge to within 15 cm of the opposite edge. If subsidiary plates are used, a similar groove is cut in one of them, which then lies centrally on the lower plate. To either side of it, flanking plates of equal thickness cover the residual area of the lower plate. The gap between the plates is closed along that side of the square on which the closed end of the groove lies, and along one adjacent edge. The enclosure for break test completely surrounds the plates.

3.1.6.3 *Break test apparatus No. III* — as shown in Fig 2C. It is an assembly of two type II cannons and two stout steel plates, each 160 × 160 × 7·5 cm in the enclosure for break test. The volume of the enclosure is 5·7 m^3. Each plate is bored centrally to be a close fit to the cannons. The plates are horizontal and are held 15 cm apart by stout pillars passing through them near the corners. The axis of the cannons are in line and vertical, and the lower end of the lower of the two cannons is closed by a steel plate. The upper surface of the lower cannon is flush with the upper surface of the lower of the two 160 cm square plates. The lower surface of the upper cannon is flush with the lower surface of the upper of the two plates. The enclosure for break test completely surrounds both plates and the mouths of both cannons; the lower part of the lower cannon may, for convenience, project below it.

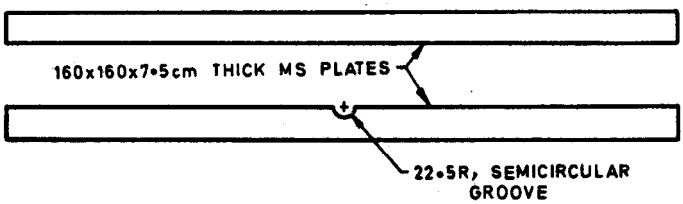
3.2 General Conditions for Testing

3.2.1 *Cartridges*

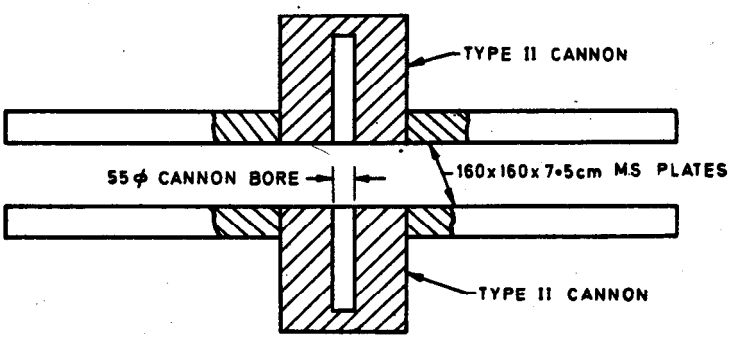
3.2.1.1 Unless otherwise required, the cartridges for all the tests on all types of explosives shall be of $36{\cdot}50 \pm {}^{1{\cdot}65}_{0}$ mm diameter excepting that in



2A Break Test Apparatus I



2B Break Test Apparatus II
(Two views at right angle to each other)



2C Break Test Apparatus III

All dimensions in millimetres.

FIG. 2 ARRANGEMENT OF BREAK TEST APPARATUS FOR P(r) EXPLOSIVES

the tests prescribed in **3.2.3.2** and **3.2.3.3**, the cartridges of Type P (eqs) or P (s) explosive of density less than 1 g/ml shall be $41{\cdot}23 \pm {}^{1{\cdot}65}_{0}$ mm in diameter. They shall not be mis-shapen and shall be filled to an approximately uniform density. The cartridges that do not fulfil these requirements shall be rejected. Fire the cartridge in the case, wrapper or in which the explosive is proposed to be employed.

3.2.2 *Priming* — While fitting the detonator, pierce the cartridge in its envelop without unfolding any part of the latter. Insert the detonator completely until its top is flush with the end of the cartridge and then give the firing lead wires a half-hitch round the cartridge.

3.2.3 *Loading and Stemming*

3.2.3.1 While loading Type I cannon for tests in the gallery, first insert a dry fireclay plug of 2·5 cm length and of diameter not less than 52 mm (*see* Note). Then load the bore of the cannon with the explosive charge for inverse or direct initiation as specified below:

a) For inverse initiation, insert the primer cartridge with the detonator to the back and make up the charge with such other cartridges as are required.

b) For direct initiation insert the primer cartridge last with the detonator to the front of the bore after having inserted the other cartridges which make up the explosive charge.

c) When stemming is specified, take a single dry fireclay plug 2·5 cm in length and 5·2 cm in diameter and fitting the bore closely, and push it on to the charge, but not with such a force as to distort the cartridge.

NOTE — In case of test prescribed in **3.3.5.1**, first insert sufficient sand to ensure that, when loaded, there shall be a space of only 5 cm between the outer end of the charge and the mouth of the cannon.

3.2.3.2 While loading Type I cannon for break test apparatus No. I, first insert enough stemming to bring the specified charge flush with the mouth of the cannon. Insert the primer cartridge first with the detonator to the back (inverse initiation).

3.2.3.3 For tests in break test apparatus No. II, lay the specified charge in the groove with its centre coincident with the centre of the groove and with the detonator nearer to the stopped end of the groove.

3.2.3.4 For loading the two Type II cannons for tests in break test apparatus No. III, first insert enough stemming in the lower cannon to fill it within 7·5 cm of the mouth. Then insert the test charge (a single cartridge 30·5 cm long) so that its lower primed end rests on the stemming; it thus bridges the gap between the plates. Then add stemming on top of the charge to fill the remaining portion of the bore of the upper cannon.

3.2.4 *Method of Firing* — Every test charge shall be fired electrically, using a strength No. 6 instantaneous copper-cased low-tension electric detonator; or, with such other type of detonator as may be used in practice with the particular explosive being tested.

NOTE — Before or during a test, shots may be fired with permitted explosives or take other steps in order to satisfy that standard conditions prevail. In particular, care shall be taken to ensure that the cannon bore has not become so enlarged as to cause any appreciable reduction of the severity of the test. The test may be suspended or discarded completely or in part, if standard conditions do not exist.

3.3 Test Procedures

3.3.1 *Procedure for Each Shot*

3.3.1.1 *Loading of the charge* — Clean the cannon bore free of greases. Load the cannon bore with appropriate quantity of the explosive as prescribed in **3.3.2**, **3.3.3**, **3.3.4** and **3.3.5.** Push the cannon so that it is kept pressed against the blank end of the gallery with which it makes a gas-tight seal. Connect the bare ends of the detonator with the first two terminals inside the gallery. Across the other two terminals, connect an electric fuse wire. Seal the vent windows and the other end of the explosion chamber using polyethylene film or bitumen impregnated paper.

3.3.1.2 *Firing of the shot into gas mixture*

a) Introduce adequate quantity of methane or natural gas and circulate for sufficient time to obtain a $9 \pm 0{\cdot}25$ percent or $8 \pm 0{\cdot}25$ percent of methane or natural gas-air mixture as the case may be (*see* **3.1.1.1** and **3.1.1.2**). Open the sampling pinch cock fitted on the gallery and draw a gas sample and check the percentage of methane in the mixture using a suitable meter. If the gas mixture is within the specified limits, stop circulation of the gas, and close all the plugcocks in the circulating system.

b) Lay the cables for firing the explosive charge and for rupturing the electric fuse wire and connect these cables to the respective terminals on the gallery. Check the circuit continuity using an approved single shot exploder or intrinsically safe circuit and fire the explosive charge, using an intrinsically safe exploder firing circuit.

c) Observe through the observation windows in the gallery from a safe distance for any gas ignition by the explosive. Also examine the polyethylene film or bitumenized kraft paper for any signs of melting or burning. In case the explosive does not ignite the gas mixture, rupture the electric fuse to ignite the gas mixture. This is done to ensure that standard condition prevails while doing the tests.

d) Record the results giving the type of explosive, charge weight, diameter, method of initiation, percentage of methane in the gas mixture, relative humidity of the atmosphere and whether it was an ignition or non-ignition.

e) Before commencing the series, check the ignitability of the gas mixture by electrically rupturing the fuse wire as above.

3.3.1.3 *Firing of shot in coal dust atmosphere*

a) The charge is loaded as described in **3.3.1.1.**

b) In case of Type P (o) explosives, place a strong wooden platform 30 cm wide and 300 cm long with its top 15 cm below the bore of the cannon in the gallery with one end touching the blank end. Scatter 2·3 kg of coal dust along the first 5·5 metres of the gallery. Lay along the first 180 cm of the platform 1·1 kg of coal dust for the first shot and 550 g of coal dust for the subsequent shots.

c) For Type P (eqs) and P (s) explosives, suspend two paper bags each containing 550 g of coal dust and a strength No. 8 copper tube low tension instantaneous electric detonator from the top of the gallery at a distance of 75 cm and 210 cm from the blank end of the gallery. Before beginning the test, scatter 2·3 kg of coal dust along the first 5·5 metres length of the gallery. Connect the detonators in the paper bag with the strength No. 6 half-second delay detonator in the explosive charge in series with each other and connect the free leads with the first two terminals inside the gallery.

d) Seal the gallery vents, windows and the end of the explosion chamber using polyethylene film or bitumen impregnated paper. Lay the cable for firing the explosive charge, connect it with the first two terminals on the gallery, check the circuit continuity and fire the shot as described in **3.3.1.2**(b). Observe for any ignition of coal dust through the observation windows in the gallery from a safe distance. Also examine the polyethylene film or bitumenized kraft paper for any sign of melting or burning. Record the results giving type of explosive, charge weight, diameter, method of initiation, relative humidity of the atmosphere and whether it was an ignition or non-ignition.

3.3.2 *Procedure for Type P (o) Explosives*

3.3.2.1 *Series 1* — Fire without stemming, 26 shots, each of 142 g inversely initiated and loaded as specified in **3.2.3.1** from a Type I cannon into the specified gas mixture contained in the gallery.

3.3.2.2 *Series 2* — Fire 5 shots, each of 795 g directly initiated and loaded and stemmed as specified in **3.2.3.1** from a Type I cannon into the specified gas mixture contained in the gallery.

3.3.2.3 *Series 3* — Before starting the series 3 proceed as mentioned in **3.3.1.3**. Then fire 5 shots, each of 795 g directly initiated and loaded and stemmed as specified in **3.2.3.1** from a Type I cannon into a cloud of coal dust of the nature and fineness specified in **3.1.2**.

3.3.3 *Procedure for Type P (eqs) Explosives*

3.3.3.1 *Series 1* — Fire 26 shots, each of 397 g inversely initiated and loaded without stemming as specified in **3.2.3.1** from a Type I cannon into the specified gas mixture contained in the gallery.

3.3.3.2 *Series 2* — Fire 5 shots, each of 1 kg directly initiated and loaded and stemmed as specified in **3.2.3.1** from a Type I cannon into the specified gas mixture contained in the steel gallery.

3.3.3.3 *Series 3* — Fire 5 shots, each of 565 g inversely initiated and loaded without stemming as specified in **3.2.3.1** from a Type I cannon into a preformed coal dust cloud. Prepare the preformed coal dust cloud in the steel gallery as mentioned in **3.3.1.3**.

3.3.4 *Procedure for Type P (r) Explosives*

3.3.4.1 *Series 1* — Fire 5 shots, each of the maximum permitted charge weight in cartridges of 36·5 mm diameter loaded as specified in **3.2.3.2** in the break test apparatus No. I specified in **3.1.6.1**, the enclosure for break test containing the specified gas mixture.

3.3.4.2 *Series 2* — Fire 26 shots at a chosen charge weight not exceeding 227 g loaded as specified in **3.2.3.3**, in break test apparatus No. II (*see* **3.1.6.2**) in an atmosphere of propane-air-nitrogen. The gas mixture shall be prepared by adding propane to air until the proportion of propane in the atmosphere is 4·00 $\pm$ 0·05 percent and then adding nitrogen to this mixture of propane and air until the proportion of propane in the mixture is 3·60 $\pm$ 0·05 percent. The gas mixture shall contain not more than negligible proportion of inflammable gases other than propane. The charge weight chosen for the test shall be that weight not exceeding 227 g at which the explosive appears to have the greatest probability of igniting the specified gas mixture. This weight shall be determined by firing shots over a range of charge weights.

3.3.4.3 *Series 3* — Fire 5 shots each of a cartridge 30 cm long and of 36·5 mm diameter, loaded and stemmed as specified in **3.2.3.4** in break test apparatus No. III specified in **3.1.6.3** the enclosure for break test containing the specified gas mixture.

3.3.4.4 *Series 4* — Fire 26 shots, each of 397 g inversely initiated and loaded without stemming as specified in **3.2.3.1** from Type I cannon into the specified gas mixture contained in the steel gallery.

3.3.5 *Procedure for Type P (s) Explosives*

3.3.5.1 *Series 1* — Fire 20 shots, each of 565 g inversely initiated and loaded without stemming as specified in **3.2.3.1** so as to allow only a distance of 5 cm between the outer end of the charge and the mouth of the cannon from a Type I cannon into the specified gas mixture contained in the steel gallery. Additional shots at charge weights lower than 565 g similarly initiated and loaded and without stemming, may also be fired.

3.3.5.2 *Series 2* — Fire 5 shots, each of 1 030 g directly initiated and loaded and stemmed as specified in **3.2.3.1** from a Type I cannon into the specified gas mixture contained in the steel gallery.

3.3.5.3 *Series 3* — Fire 5 shots, each of 565 g inversely initiated and loaded without stemming as specified in **3.2.3.1** from a Type I cannon into a preformed coal dust cloud. Prepare the preformed coal dust cloud in the steel gallery as mentioned in **3.3.1.3**.

4. TEST FOR CONTINUITY OF DETONATION

4.0 General — The object of this test is to determine whether detonation developed in the first cartridge of a one-metre column of explosives can be maintained throughout the length of the column.

4.1 Procedure — Make a one metre long column of cartridges of the smallest diameter and of the smallest mass in that diameter to be manufactured. Keep them in loose contact without any confinement in a three-fold manila paper or any other paper used for wrapping the explosive under test on a steel bar or rail. Initiate the end cartridge by a detonator of the type recommended by the manufacturer for use along with this explosive. Observe whether the cartridges have detonated or not.

4.2 Precautions — The following precautions shall be observed:

a) In case of detonator failing to fire, wait at least for 10 minutes before approaching the shot.

b) In case of incomplete detonation of the column, collect all undetonated cartridges carefully and destroy by detonation.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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Printed at Simco Printing Press, Delhi, India